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CHEMICAL STUDIES ON COFFEE GROWN IN THE PHILIPPINES
I. THE NONNITROGENOUS ORGANIC ACIDS OF THE LEAVES, SHELLS, AND BEANS [1]

APOLINARIO R. CARAÑGAL, JR., SYLVIA R. ARNALDO, and ERLINDA A. TUCAY [2]

Acetic, formic, oxalic, malic, citric, and an unidentified acid (lactic and/or succinic) were found in the leaves, shells, and beans of *Coffea robusta, C. liberica,* and *C. excelsa.* Lactic-succinic and oxalic acids were the predominant acids in the leaves and dried shells; citric acid was predominant in the raw and roasted beans of the three species. The acetic acid content was higher in the roasted beans than in the raw beans. The other acids were not affected by roasting.

Healthy portions of *Coffea arabica* leaves infected with coffee rust had more lactic-succinic acid but less citric and malic acids than the infected parts.

This paper is the first report on a series of studies on the chemical constituents of coffee. It deals with the nonnitrogenous organic acids, substances of biological importance which are perhaps involved in what coffee roasters call the "acidity in a cup of coffee." The information may be of importance to other workers on coffee and ultimately to the consuming public in terms of improved quality of coffee.

The literature on the nonnitrogenous acids of coffee is meager. Winton and Winton (1935), in citing the studies of various investigators, mentioned the occurrence in coffee of malic and oxalic acids together with the volatile acids, acetic and formic acids. Jacobs (1951) stated that the actual acidities of some East Indian coffees vary from 0.013 to 0.033 per cent and are probably made up mainly of volatile acids with other acidic natural products of roasting.

EXPERIMENTAL PROCEDURE

The leaves, shells, raw and roasted beans of *Coffea liberica, C. robusta,* and *C. excelsa* species of coffee were dried in a forced-draft

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[1] Central Experiment Station Contribution No. 1896. Progress report of Research Project No. 801. Conducted in the Department of Agricultural Chemistry.

[2] The writers thank Dr. J. Mondoñedo of the Department of Agronomy and Dr. F. T. Orillo of the Department of Plant Pathology for the samples used in this study.

oven at 80°C. for 24 hours. The dried samples were divided into lots, ground separately in a Wiley mill, and stored in a desiccator prior to determination of their organic acid content. The leaves were ground with 4.0 NH_2SO_4, extracted with ether for 24 hours, and the acids recovered from the ether extract as their sodium salts. Healthy and diseased parts of *C. arabica* leaves infected with coffee rust were cut out, divided into three lots, and analyzed separately.

Ether extraction was discontinued because of shortage of water for the condenser, and the shells and raw and roasted beans were instead extracted with hot distilled water (70°-80°C.) for two to three hours and filtered through cotton while hot. The filtrate and the washings were made alkaline with 0.05 N NaOH and concentrated to a small volume on a hot plate.

The chromatographic analysis on silica gel column, determination, and tentative identification of the acids in the extracts were done according to the method of Bulen, Varner, and Burrell (1952). Results were expressed as number of milliequivalents of acid per gram dry weight. The procedure involved the determination of both free and combined acids. Errors in the method may have arisen from the loss of some volatile acids during the drying and water extraction of the samples.

DISCUSSION OF RESULTS

Acids in leaves. The leaves of *Coffea robusta, C. liberica,* and *C. excelsa* had the same kinds of acids (table 1). Acetic, oxalic, malic, and citric acids were identified by their displacement volumes. The acids belonging to the formic group (formic, alpha-ketoglutaric, and fumaric) were present in negligible amounts. Titration values were obtained at the point of emergence of lactic and succinic acids. The eluate corresponding to these acids were not identified by chemical tests because of the lack of the necessary reagents and are referred to as unidentified acid (lactic and/or succinic) in the subsequent discussion. This acid fraction is probably succinic or predominantly succinic acid since this acid is reported to be present in many species of plants under normal conditions. Lactic acid, on the other hand, is usually associated with the deterioration of the sample and the action of microorganisms.

Coffea robusta had an unusually high content of oxalic acid, whereas *C. arabica* and *C. liberica* had the lowest amounts.

TABLE 1.—*Average organic acid content of different species of coffee*[a]

SPECIES AND PARTS ANALYZED	ACETIC	FORMIC GROUP	LACTIC SUCCINIC	OXALIC	MALIC	CITRIC
	milliequivalents × 10^2*/gram dry weight*					
C. liberica						
Raw beans	1.68	0.37	1.84	1.30	2.47	5.96
Roasted beans	1.82	1.15	2.23	1.05	2.06	4.58
Shells	2.79	1.40	22.46	21.45	2.07	6.75
Leaves	1.38	trace	11.95	6.04	2.40	4.73
C. robusta						
Raw beans	0.67	0.78	3.86	1.52	2.67	4.46
Roasted beans	2.26	0.73	2.19	1.44	2.46	4.21
Shells	0.93	1.87	15.86	6.30	8.80	3.56
Leaves	2.03	trace	10.35	25.60	2.03	4.27
C. excelsa						
Raw beans	0.79	0.40	2.22	0.93	2.03	3.46
Roasted beans	2.59	0.51	2.09	0.60	2.38	3.79
Shells	0.78	2.07	18.45	5.35	5.07	3.35
Leaves	0.85	trace	11.43	10.53	4.44	1.70
C. arabica						
Leaves	1.57	trace	11.95	6.04	2.40	4.73

[a] Average results of three determinations.

The organic acids contained in the leaves of *C. arabica* infected with coffee rust are presented in table 2. There seemed to be a decrease in the amount of lactic-succinic ácids and accumulation of citric and malic acids as a result of the infection. Inconsistent results were obtained in the case of oxalic acid. In terms of the total acids, the normal parts of the leaves had 0.176 to 0.193 ml., whereas the infected parts had 0.178 to 0.221 ml. of normal alkali per gram

TABLE 2.—*Effect of coffee rust on the organic acids of leaves of Coffea arabica*

SAMPLE	TRIAL	ACETIC	FORMIC GROUP	LACTIC SUCCINIC	OXALIC	MALIC	CITRIC
		milliequivalents × 10^2*/gram dry weight*					
	I	3.06	0.28	5.13	4.21	3.68	1.22
Normal	II	2.74	trace	5.06	6.83	3.27	1.37
	III	1.90	trace	7.39	3.78	3.26	1.43
Diseased							
	I	1.84	0.33	4.88	3.37	4.03	4.41
Early stage	II	3.16	0.29	4.51	2.63	4.71	2.53
	III	4.04	trace	4.00	4.67	4.35	4.63
	I	3.29	trace	3.34	4.33	5.83	5.26
Advanced stage	II	2.01	0.30	3.39	3.81	6.41	6.00
	III	3.04	trace	4.35	5.90	8.53	7.59

dry weight during the early stage and 0.216 to 0.294 ml. during the advanced stage. Manotas (1953) reported that cacao pods at the stages of fungal attack had high glucose, organic acids, and pectins. Perhaps the unidentified, malic, and citric acids are related to the coffee rust disease.

Coffea robusta, C. liberica, and *C. excelsa* are usually resistant to the coffee rust disease. These species and *C. arabica* were found to have the same kinds of acids in their leaves, but in different amounts. More evidence has yet to be found to confirm whether or not these differences are associated with the resistance of each species to coffee rust.

Hughes and Fowler (1953) reported that a high glucose content of the leaf was associated with the resistance of the cotton plant to the blackarm disease. Otani (1952) found that the soluble organic nitrogenous components of the rice plant, but not its glucose content, was related to its susceptibility to the blast disease.

Acids in shells. Dried shells of *C. liberica, C. robusta,* and *C. excelsa* showed lactic and/or succinic acids to be predominant (table 1). *C. liberica* had a high amount of oxalic acid compared to the other species. The other acids present were acetic, formic, oxalic, malic, and citric acids. Presumably some of these acids, especially those of the lactic group, were formed during the process of drying of the berries and as a result of the action of microorganisms. The malic acid content of the three species was 0.10 to 0.56 per cent of the dry weight, and the oxalic acid content was 0.17 to 1.06 per cent. Herndlhofer (1933) examined all parts of the coffee tree for acids and found that malic and oxalic acids are located entirely in the shells.

Acids in beans. The same kinds of acids were present in the the raw and roasted beans of all the species (table 1). Citric acid was the predominant acid. The acidity of the water extracts of the raw beans of the three species was 8.5 to 15.8 ml. of 1.0 N NoOH per 100 grams, and that of the roasted beans, 10.8 to 16.3 ml. These values represent the free and combined acids and are considerably lower than the 13.9 to 33.4 ml. N alkali per 100 grams reported by Warnier as cited by Winton and Winton (1935).

Except for the citric and lactic and/or succinic acids, all the acids have been reported present in the beans by various workers. The amount of oxalic acid, 0.0113 to 0.109 per cent, is comparable to

the 0.08 per cent reported by Arbenz (1917) and the 0.04 per cent reported by Widmark and Ahldin (1953).

Roasting affected neither the quality nor the quantity of the acids, except acetic acid. The acetic acid content increased significantly during roasting. Other workers report that considerable amounts of acetic acid and traces of formic acids are formed during roasting; however, retention is very low because of the volatility of these acids.

Comparison of acid contents of the leaves, shells, and beans. Lactic and/or succinic and oxalic acids were present in higher amounts in the shells and leaves than in the beans (table 1). In the shells and leaves, the predominant acid was lactic and/or succinic acid; in the beans it was citric acid. The oxalic acid content of the shells was 5 to 11 times more than that of the roasted beans; the unidentified acid content, about 10 to 13 times. The levels of these acids in the roasted beans may serve as an index of the quality of shelling of the dried berries or the degree of adulteration of the beans with shells.

The acids of the different species were not compared because the sources of materials were not subjected to similar cultural conditions. Fertilization is known to affect the organic acid metabolism of the plant (Pierce and Appleman, 1943).

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THE EFFECT OF DIFFERENT RATES OF NITROGEN ON THE YIELD AND CHEMICAL COMPOSITION OF CORN [1]

N. L. GALVEZ, E. A. OCHAVILLO, F. S. MELODIA, N. C. BRADY, I. T. CORPUZ, N. B. NAZARENO, and A. B. LOPEZ

The average mean grain yields and nitrogen contents of the corn hybrids and open--pollinated varieties were increased by the rates of nitrogen application. The phosphorus in the grains was inconsistently correlated with the rates of nitrogen application. The effects of the different rates of nitrogen on stover yields and their nitrogen and phosphorus contents were not consistent.

The total recovery of nitrogen in Maquiling, Calamba, decreased as the rate of nitrogen application increased. The uptake of soil phosphorus increased as the nitrogen levels were increased.

Increased corn yield in the United States derives mainly from the use of hybrids and fertilizers. While the performance of some corn hybrids in the Philippines is promising, their response to fertilization is still undetermined.

In 1945 Krantz, as cited by Jones and Rogers [2] and Ohlroge *et al.*,[3] reported that where nitrogen is the limiting factor, about 1 bushel of corn is produced for every 2 pounds of applied commercial nitrogen.

Krantz, in 1947, found that nutrient balance was the key to high yields. Dunbar sandy loam produced a striking increase for nitrogen when potash was supplied, but no increase occurred without potash.

The response of corn hybrids and open-pollinated varieties to different levels of nitrogen, each with 90 kg. of P_2O_5 and K_2O, was studied in cooperation with farmers in the Mt. Makiling area. The presence of any variety $\times$ fertilization interaction was also determined.

MATERIALS AND METHODS

Two field tests were carried out in representative corn areas in the province of Laguna: in Lalakay, Los Baños, and in Maquiling, Calamba. Both soils are classified as Lipa loam (table 1). The chemical constituent of the soils which might be critical is nitrogen. The or-

[1] Central Experiment Station Contribution No. 1897.

[2] R. J. Jones and H. T. Rogers, "Advances in Agronomy," Academic Press Inc., Publishers, New York, 1949, Vol. 1, pp. 54-59.

[3] A. J. Ohlroge *et al.*, *Amer. Soil Sci. Soc. Proc.*, 8, 196 (1944).

ganic matter, which is the main source of nitrogen, was only 1.20 per cent in Lalakay soil and 1.69 per cent in Maquiling soil. Previous experiments in these two areas showed good response of corn to nitrogen but not to phosphorus and potassium.

TABLE 1.—*Chemical analyses of soils*

CONSTITUENT	LIPA LOAM	
	Lalakay, Los Baños, Laguna CF-5	Maquiling, Calamba, Laguna CF-7
pH	6.33	5.55
Organic matter (%)	1.20	1.69
Available P, ppm.	56.87	26.63
C.E.C. m.e./100 gram	15.87	34.10
Ca "	8.4	15.37
Mg "	4.81	5.38
K "	1.18	1.68
Na "	1.17	3.84
Mn "	trace	0.05

The seeds were supplied by the Division of Plant Breeding, Department of Agronomy. In the Lalakay test five hybrids and three varieties were used: hybrids (1) (A105 × A106) × (A114 × A115), double crosses of College Yellow and Cuban lines; (2) (A105 × A-109) × (A113 × A114); (3) (19 × 112) × (A110 × A112), single crosses of introduced lines from Georgia by a single cross of Cuba; (4) (193 × 194) × (A111 × A112), single crosses of introduced lines from Columbia, South America, by a single cross of Cuba; (5) (118 × 180) × (A112 × A114); varieties (1) Cuban; (2) Catambay's Cuban; (3) College Yellow.

In the Maquiling test, six hybrids and two varieties were used: hybrids (1) (117 × 118) × (A102 × A103); (2) (A102 × A104) × (A110 × A112); (3) (A110 × A113) × (A102 × A103); (4) (A104 × A107) × (A112 × A113); (5) (A110 × A113) × (A102 × A106); (6) (193 × 194) × (A102 × A106); varieties (1) College Yellow; (2) Cuban Yellow.

Nitrogen was supplied as ammonium sulfate containing 20 per cent N; phosphorus as superphosphate containing 18 per cent P_2O_5; potassium as muriate of potash containing 60 per cent K_2O.

In the Lalakay test the corn was grown without irrigation in land prepared by the tenant-cooperator. A split-plot design was employed with three replications. Three levels of nitrogen, 0, 45, and 90 kg.,

were assigned to the main plots, and the eight hybrids and varieties to the subplots. Each subplot was 6 × 3.5 meters and contained five rows, 0.7 meter apart, with two-plant hills 0.5 meter apart. The seeds were planted on December 31, 1953, at the rate of three to four seeds to a hill. The plants were thinned to the desired stand two weeks after planting.

Each plot received 90 kg. P_2O_5 and 90 kg. K_2O. One-half of the nitrogen and all of the phosphorus and potasium were applied in bands around the hills at the time of planting. The remainder of the nitrogen was applied on the side of each hill five weeks after planting. The corn was harvested in April, 1954.

In the Maquiling test, preparation of the land, planting, and fertilization were similar to those in the first test. The size of each plot, however, was 1.5 × 4 meters. The four treatments were as follows: 0, 45, 90, and 135 kg. N with a blanket application to all plots of 90 kg. P_2O_5 and 90 kg. K_2O. The corn was planted on June 22 and harvested on October 7, 1954.

RESULTS AND DISCUSSION

Grain yield and fertilization. The average yields of shelled corn of the five hybrids and three varieties tested in Lalakay were significantly increased by nitrogen fertilization (table 2). At 45 kg. N the yield was 25.6 cavans higher than at no N. At 90 kg. N the yield

TABLE 2.—*Mean yield of shelled corn in cavans/ha. (15 per cent moisture) at Lalakay, Los Baños, Laguna*

CORN	NITROGEN TREATMENT			HYBRID OR VARIETY MEAN
	0	45	90	
Hybrids:				
(A105 × A106) × (A114 × A115)	26.6	53.6	60.5	46.9
(A105 × A109) × (A113 × A114)	21.0	37.4	47.6	35.4
(19 × 112) × (A110 × A112)	25.2	54.7	63.3	47.7
(193 × 194) × (A111 × A112)	20.0	56.6	71.6	49.5
(118 × 180) × (A112 × A114)	24.8	43.2	67.0	45.1
Varieties:				
Cuban	19.8	47.2	58.2	41.7
Catambay's Cuban	22.2	48.5	57.3	43.7
College Yellow	19.1	41.5	46.5	35.7
Nitrogen mean	22.3	47.9	59.1	

LSMD N (5%)—5.0; (1%)—8.6
HV (5%)—6.3; (1%)—8.5
HV × N—Not significant.

was 36.8 cavans higher than at 0 kg. N. The interaction between hybrids and varieties and treatments was not significant.

The mean yields of each hybrid and variety at all fertility levels varied significantly from each other. The high yielders in descending order were hybrids 4, 3, 1, and 5 and varieties 2 and 1. The low yielders were hybrid 2 and variety 3.

In the Maquiling experiment the average yields of the six hybrids and two varieties of corn were also closely associated with the rates of nitrogen application (table 3). With 45 kg. N the yield was increased by 22.2 cavans per hectare. The yields increased further with additional N, but the maximum economic yield was at 45 kg. As in the other test, the interaction was not significant.

TABLE 3.—*Mean yield of shelled corn in cavans/ha. (15 per cent moisture) at Maquiling, Calamba, Laguna*

CORN	NITROGEN TREATMENT				HYBRID OR VARIETY MEAN
	0	45	90	135	
Hybrids:					
(117 ×118) × (A102 × A103)	7.2	25.5	28.2	40.5	25.3
(A102 × A104) × (A110 × A112)	13.5	34.0	42.1	48.6	34.5
(A110 × A113) × (A102 × A103)	11.8	34.2	44.0	44.3	35.5
(A104 × A107) × (A112 × A113)	15.7	37.0	43.3	41.0	34.2
(A110 × A113) × (A102 × A106)	8.2	25.1	39.6	45.4	29.6
(193 × 194) × (A102 × A106)	6.9	39.7	42.2	53.9	37.0
Varieties:					
College Yellow	11.2	25.6	39.1	35.3	27.8
Cuban Yellow	6.3	37.0	33.4	37.0	28.4
Nitrogen mean	10.1	32.3	39.6	43.2	

LSMD N (5%)—2.51; (1%)—3.61
H (5%)—5.83; (1%)—7.72
HV × N—Not significant.

At all fertility levels, hybrids 6, 2, 3, and 4 were better yielders than hybrids 1 and 5 and varieties 1 and 2. All hybrids except one produced higher yields than either variety.

The findings of these two variety-fertility tests are in accord with those of Moores,[4] Stringfield and Salter,[5] and Viets and Domingo.[6]

[4] C. A. Moores, *Jour. Amer. Soc. Agron.*, 25, 196 (1933).
[5] G. H. Stringfield and R. M. Salter, *Jour. Agric. Res.*, 49, 991 (1934).
[6] F. G. Viets and C. E. Domingo, *Amer. Soil Sci. Proc.*, 13, 303 (1948).

Nitrogen and phosphorus contents of grains. The nitrogen content of the grains increased significantly with increased rates of nitrogen (table 4). The interaction between hybrids-varieties and treatments was not significant.

TABLE 4.—*Effects of three levels of nitrogen on nitrogen and phosphorus contents of corn grains in Lalakay, Los Baños*

CORN	0 N		45 N		90 N		HYBRID OR VARIETY MEAN	
	N	P	N	P	N	P	N	P
	%		%		%		%	
Hybrid:								
(A105 × A106) × (A114 × A115)	0.81	0.42	1.49	0.82	1.54	0.85	1.28	0.70
(A105 × A109) × (A113 × A114)	1.50	0.29	1.60	0.39	1.98	0.32	1.69	0.33
(19 × 112) × (A110 × A112)	0.74	0.41	1.36	0.62	1.49	0.61	1.21	0.55
(193 × 194) × (A111 × A112)	1.15	0.38	1.43	0.77	1.30	0.70	1.29	0.62
(118 × 180) × (A112 × A114)	1.35	0.35	1.49	0.28	1.83	0.28	1.56	0.30
Varieties:								
Cuban	1.54	0.30	1.55	0.32	1.90	0.20	1.66	0.28
Catambay's Cuban	1.32	0.29	1.64	0.40	1.80	0.24	1.59	0.31
College Yellow	1.40	0.38	1.34	0.74	1.64	0.69	1.46	0.61
Nitrogen mean	1.23	0.35	1.49	0.54	1.68	0.49	1.47	0.46

LSMD (5% and 1%, respectively)
Nitrogen content
N—0.14; 0.23
HV—0.18; 0.24
N × HV—Not significant.
Phosphorus content
N—0.078; 0.13
HV—0.073; 0.10
N × HV—0.121; 0.32

Hybrid 2 and variety 1 showed the highest nitrogen contents, followed by variety 2, hybrid 5, variety 3, hybrids 4 and 1, and hybrid 3 in the descending order.

The amount of phosphorus in the grains showed inconsistent correlation with the rates of nitrogen application. At both the 45 and 90 kg. rates the phosphorus content increased. At 90 kg. the phosphorus content was not significantly different from that at 45 kg.

TABLE 5.—*Effects of four levels of nitrogen on nitrogen and phosphorus contents of corn grains at Maquiling, Calamba*

CORN	0 N		45 N		90 N		135 N		HYBRID OR VARIETY MEAN	
	N	P	N	P	N	P	N	P	N	P
Hybrids:		%		%		%		%		
(117 × 118) × (A102 × A103)	1.59	0.27	1.46	0.31	1.62	0.29	1.71	0.20	1.57	0.27
(A102 × A104) × (A110 × A112)	1.37	0.31	1.47	0.22	1.69	0.21	1.92	0.22	1.61	0.24
(A110 × A113) × (A102 × A103)	1.41	0.19	1.55	0.18	1.81	0.30	1.89	0.27	1.66	0.24
(A104 × A107) × (A112 × A113)	1.34	0.27	1.46	0.29	1.74	0.31	1.81	0.23	1.59	0.27
(A110 × A113) × (A102 × A106)	1.35	0.28	1.34	0.29	1.70	0.32	1.62	0.24	1.50	0.28
(193 × 194) × (A102 × A106)	1.35	0.25	1.24	0.18	1.59	0.27	1.64	0.32	1.45	0.26
Varieties:										
College Yellow	1.39	0.29	1.54	0.31	1.66	0.23	1.77	0.30	1.59	0.28
Cuban Yellow	1.41	0.34	1.41	0.28	1.51	0.25	1.81	0.31	1.59	0.29
Nitrogen mean	1.39	0.28	1.43	0.26	1.67	0.27	1.76	0.26	1.56	0.27

LSMD (5% and 1%, respectively)

Nitrogen content

N—0.07; 0.10

HV—0.08; 0.12

N × HV—Not significant.

Phosphorus content

N—Not significant.

HV—0.038

N × HV—0.076; 0.10

The highest percentages of phosphorus were recorded for the grains of hybrids 1 and 4, variety 3, and hybrid 3.

In the experiment at Maquiling, Calamba, the nitrogen content of the grains was also closely associated with rates of nitrogen application (table 5). This confirms the finding of Viets and Domingo (1948) that nitrogen fertilization increased substantially the nitrogen content of the grains. The interaction between hybrids and treatments was not significant.

Hybrids 3, 2, 4, and 1 and varieties 1 and 2 contained higher percentages of nitrogen than hybrids 5 and 6.

The phosphorus content of grains was not increased by the nitrogen treatments. Phosphorus concentration in the grains differed with the hybrid or variety. Likewise, there was interaction between nitrogen level and hybrids and varieties.

Varieties 2 and 1 and hybrids 5, 1, and 6 showed higher percentages of phosphorus than hybrids 2 and 3.

Stover yields. Yields of stover at Lalakay, Los Baños, were not recorded. In Maquiling, Calamba, 45 kg. N produced a highly significant increase in stover yield (table 6). At 90 kg. N level, the yield was as high as that at the 45 kg. level. The 135 kg. rate produced a significantly higher yield than the 90 kg. rate.

TABLE 6.—*Effects of four levels of nitrogen on yield of corn stover in kg./ha. at Maquiling, Calamba*

CORN	NITROGEN TREATMENT				HYBRID OR VARIETY MEAN
	0	45	90	135	
Hybrids:					
(117 × 118) × (A102 × A103)	922	3321	3404	3965	2903
(A102 × A104) × (A110 × A112)	1302	3166	3267	4231	2992
(A110 × A113) × (A102 × A112)	1278	2657	1893	2609	2109
(A104 × A107) × (A112 × A113)	988	3433	3707	4070	3050
(A110 × A113) × (A102 × A106)	959	2816	3662	3009	2612
(193 × 194) × (A102 × A106)	1183	3204	2219	3596	2551
Varieties:					
College Yellow	811	2245	2797	2623	2119
Cuban Yellow	609	2529	2644	2482	2066
Nitrogen mean	1007	2921	2949	3323	

LSMD N (5%)—289; (1%)—415
HV (5%)—332; (1%)—440
HV × N—Not significant.

Hybrids 1, 2, and 4 showed higher stover yields than hybrids 5 and 6. Hybrid 3 and varieties 1 and 2 produced the lowest yields.

Nitrogen and phosphorus contents of stover. Unlike the nitrogen content of the grains, that of the stover was not affected by rate of nitrogen fertilization in Lalakay, Los Baños (table 7). There was, however, a significant interaction between nitrogen levels and hybrids and varieties.

TABLE 7.—*Effects of three levels of nitrogen on nitrogen and phosphorus contents of corn stover at Lalakay, Los Baños*

CORN	0 N		45 N		90 N		HYBRID OR VARIETY MEAN	
	N	P	N	P	N	P	N	P
	%		%		%		%	
Hybrids:								
(A105 × A106) × (A114 × A115)	0.34	0.40	0.38	0.23	0.40	0.17	0.37	0.27
(A105 × A109) × (A113 × A114)	0.53	0.27	0.50	0.24	0.54	0.15	0.52	0.22
(19 × 112) × (A110 × A112)	0.24	0.33	0.29	0.18	0.46	0.17	0.33	0.22
(193 × 194) × (A111 × A112)	0.29	0.33	0.32	0.16	0.42	0.16	0.34	0.22
(118 × 180) × (A112 × A114)	0.41	0.30	0.54	0.18	0.56	0.13	0.51	0.20
Varieties:								
Cuban	0.51	0.28	0.49	0.16	0.51	0.09	0.50	0.21
Catambay's Cuban	0.43	0.37	0.60	0.15	0.60	0.10	0.54	0.21
College Yellow	0.41	0.33	0.41	0.19	0.56	0.19	0.46	0.24
Nitrogen mean	0.40	0.34	0.44	0.18	0.51	0.14	0.45	0.22

LSMD (5% and 1%, respectively)
Nitrogen content
N—Not significant.
HV—0.059; 0.081
HV × N (5%)—0.14
Phosphorus content
N—0.025; 0.041
HV—Not significant.
HV × N—Not significant.

Hybrids 2 and 5 and varieties 1, 2, and 3 contained higher percentages of nitrogen in the stover than hybrids 1, 3, and 4.

The phosphorus content was decreased by nitrogen fertilization. The contents of the individual hybrids and varieties were statistically similar to each other.

TABLE 8.—*Effects of four levels of nitrogen on the nitrogen and phosphorus contents of stover at Maquiling, Calamba*

CORN	0 N		45 N		90 N		135 N		HYBRID OR VARIETY MEAN	
	N	P	N	P	N	P	N	P	N	P
Hybrids:										
(117 × 118) × (A102 × A103)	0.43	0.17	0.49	0.11	0.72	0.11	0.75	0.11	0.59	0.13
(A102 × A104) × (A110 × A112)	0.41	0.15	0.46	0.11	0.72	0.14	0.69	0.08	0.57	0.12
(A110 × A113) × (A102 × A112)	0.51	0.18	0.60	0.09	0.65	0.13	0.90	0.08	0.66	0.12
(A104 × A107) × (A112 × A113)	0.59	0.14	0.65	0.12	0.69	0.10	0.73	0.09	0.66	0.11
(A110 × A113) × (A102 × A106)	0.51	0.16	0.56	0.14	0.65	0.08	0.82	0.08	0.63	0.12
(193 × 194) × (A102 × A106)	0.59	0.17	0.51	0.09	0.69	0.08	0.91	0.09	0.67	0.11
Varieties:										
College Yellow	0.85	0.14	0.61	0.11	0.67	0.07	0.86	0.09	0.74	0.10
Cuban Yellow	0.52	0.17	0.52	0.10	0.78	0.13	0.74	0.10	0.64	0.13
Nitrogen mean	0.55	0.16	0.55	0.11	0.70	0.11	0.80	0.09		

LSMD (5% and 1%, respectively)
Nitrogen content
N—0.08; 0.11
HV—0.08; 0.12
HV × N (5%)—0.29
Phosphorus content
N—0.03; 0.05
HV—Not significant.
HV × N—Not significant.

Table 8 shows the nitrogen and phosphorus contents of the stover in the Maquiling test. The 45 kg. rate did not increase the nitrogen content. At the 90 kg. N level a significant increase of 0.15 per cent was obtained, and at the 135 kg. N level, a significantly higher increase.

Hybrids 3, 4, and 6 and variety 1 showed higher percentages of nitrogen than the rest.

The percentage of phosphorus in the stover from the no-nitrogen plots tended to be higher than that from the nitrogen-treated plots. The stover yield increase of the nitrogen-treated plots might have resulted in the dilution of the phosphorus content. Hybrid 1 and variety 2 showed higher phosphorus contents than the other hybrids and varieties.

Total nitrogen and phosphorus of grains and stover. The total nitrogen contents of corn plants, excluding the cob, in Maquiling, Calamba, varied from 8.1 to 81.4 kg. per hectare (table 9). The largest uptake by the corn plants was shown by hybrid 4, and the lowest, by variety 2.

TABLE 9.—*Total N in kg./ha. of corn grain and stover at Maquiling, Calamba*

CORN	NITROGEN TREATMENT				HYBRID OR VARIETY MEAN
	0	45	90	135	
Hybrids:					
(117 × 118) × (A102 × A103)	10.1	37.12	50.09	68.52	41.44
(A102 × A104) × (A110 × A112)	15.70	42.55	63.36	81.43	50.76
(A110 × A113) × (A102 × A112)	15.84	45.63	56.90	70.37	47.19
(A104 × A107) × (A112 × A113)	17.61	52.56	67.77	71.27	52.30
(A110 × A113) × (A102 × A106)	11.09	34.61	61.50	65.86	43.27
(193 × 194) × (A102 × A106)	12.20	43.91	52.88	82.22	47.80
Varieties:					
College Yellow	15.61	35.77	55.09	57.55	41.01
Cuban Yellow	8.14	42.37	48.86	55.87	38.81
Nitrogen mean	13.28	41.82	57.06	69.14	
Applied N recovered in per cent		63.4	48.6	41.4	

In general the heavy forager for nitrogen in the Maquiling test at all fertility levels was also a good grain yielder (table 3).

Table 10 shows that the utilization of the soil phosphorus by the corn plants was influenced by the rates of nitrogen application.

The increases in uptake of soil phosphorus were 4.57, 5.86, and 6.17 kg. for the 45, 90, and 135 kg. N levels, respectively.

TABLE 10.—*Total P in kg./ha. of corn grain and stover at Maquiling, Calamba*

CORN	NITROGEN TREATMENT				HYBRID OR VARIETY MEAN
	0	45	90	135	
Hybrids:					
(117 × 118) × (A102 × A103)	2.66	8.08	8.32	8.90	6.99
(A102 × A104) × (A110 × A112)	4.29	7.67	9.52	9.37	7.71
(A110 × A113) × (A102 × A103)	3.56	5.84	9.85	8.79	7.01
(A104 × A107) × (A112 × A113)	3.75	10.13	11.23	8.94	8.51
(A110 × A113) × (A102 × A106)	2.82	8.02	9.94	8.51	7.32
(193 × 194) × (A102 × A106)	2.98	6.88	8.16	12.90	7.73
Varieties:					
College Yellow	2.96	6.91	7.00	8.29	6.29
Cuban Yellow	2.24	8.33	8.12	8.90	6.90
Nitrogen mean	3.16	7.73	9.02	9.33	
Increase in uptake of phosphorus		4.57	5.86	6.17	
Increase in uptake of phosphorus as percentage of control		144.6	185.4	195.2	

The data reveal further that the hybrids and varieties which were comparatively more efficient in absorbing the applied nitrogen were also good foragers of phosphorus at all nitrogen levels.

REACTION OF VARIETIES OF ABACÁ AND ITS RELATIVES TO VASCULAR DISEASE [1]

D. L. Umali, F. R. Ick, and F. T. Orillo

Of 578 seedlings of abacá varieties and their crosses, pacol × abacá hybrids, pacol, and canton, only canton showed resistance to the vascular disease of abacá caused by *Fusarium oxysporum* Schlecht. var. *cubense* Wr. & Rkg. The symptoms of wilt in abacá seedlings are yellowing of the foliage, bunching of the leaves, stunting of the plants, and discoloration of the vascular bundles. The external indications of wilt infection are noticeable from one to three months after inoculation.

The wilt or vascular disease of abacá (*Musa textilis* Née) known locally as *bahi* is caused by *Fusarium oxysporum* Schlecht. var. *cubense* Wr. & Rkg.

Leoncio (1930) reported that in 1927 young abacá plants grown from seeds in Panama and Central America were infected with a disease similar to banana wilt. He proved conclusively that the fungus *Fusarium oxysporum* Schlecht. f. 3 Wr. causes abacá wilt. A similar wilt disease of abacá was reported by Ocfemia in 1937 to be very serious in Davao, especially at high altitudes (Castillo and Celino, 1940).

Lee and Serrano (1923), Teodoro (1925), and Teodoro and Serrano [2] reported that the heart rot of abacá in the Philippines is caused by a fungus similar to, if not identical with, *Fusarium cubense*. Ocfemia (1927), however, does not believe that the vascular fungus *Fusarium cubense* can cause the heart rot of abacá.

The vasuclar disease of abacá is now becoming prevalent in Davao. If not checked in time, it may entail severe losses to the abacá industry. A means of controlling the disease which in the long run may prove cheaper and more permanent is the breeding of resistant clones of abacá. To ascertain the resistance of the parental stocks which may be used in the breeding of resistant clones, this investigation was conducted from November, 1953, to February, 1955.

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[1] Central Experiment Station Contribution No. 1898.

[2] N. G. Teodoro and F. B. Serrano, *Philippine Bureau Agric. Cir.*, 190, (1926).

MATERIALS AND METHODS

A total of 1156 seedlings and suckers of abacá, intervarietal crosses of abacá, pacol x abacá hybrids, pacol, and canton was divided into two groups. One group was tested for resistance, and the other group was used as control. The experimental seedlings and suckers were dipped into a heavy spore suspension of the fungus *Fusarium oxysporum* Schlecht. var *cubense* Wr. and Rkg. They were then planted in seed boxes and pots filled with disinfected clay loam soil. After one week in the nursery the seedlings were placed outside under partial shade for observation.

All seedlings that did not show symptoms of the disease were reinoculated several times; the spore suspension was poured at the base of the pseudostem which had been previously pricked with needles.

RESULTS AND DISCUSSION

Symptoms of wilt of abacá. The first noticeable symptoms of the disease on the seedlings are the inward curling of the leaf blades at or near the tip of the lower leaves and the slow growth of the plants. After about a month, the lower leaves show a loss of turgidity and gradually droop or wilt from the tip downward. Then the blades turn from yellow to yellowish brown.

As infection advances, more of the lower leaves wilt. The new leaves which appear are reduced in size, and they soon wilt and dry up. The petioles bunch conspicuously at the upper end of the pseudostem. Splitting of the pseudostem from the base upwards, characteristic of the wilt of Latundan banana (*Musa sapientum* Linn. var. cinerea [Blanco] Teodoro), is not observed. When corms of the wilted plants are cut open, a reddish-violet discoloration of the vascular bundles is evident. In more advanced cases, the roots and corms of infected plants gradually rot.

Varieties which become diseased as a result of inoculation with pure cultures of abacá wilt fungus show stunted growth of the stalk and conspicuous wilting of the lower leaves.

Degree of infection of the plants. On June 8, 1954, 578 two- to three-month-old seedlings and suckers were inoculated by the method previously described: (1) abacá varieties Boñgolanon, Camarahon, Experiment Station No. 3, Inosa, Maguindanao, and Tangongon; (2) intervarietal crosses of abacá Bulaoluna x Magsarapong, Kurisan x Magsarapong, Magsarapong x Inisarog, Putian x

Kurisan, Putian x Magsarapong, and Ugaram x Magsarapong; (3) pacol x abacá and wild banana (*Musa lolodensis*); (4) pacol; and (5) canton. An equal number of plants were used as checks. All the experimental and check plants recovered from the effects of transplanting two weeks after.

Three weeks after inoculation, 73 pacol seedlings and all of the wild banana and pacol x abacá seedlings showed wilting of the lower leaves (table 1). One week later, all the pacol seedlings showed similar symptoms. All the infected wild bananas and pacol x abacá hybrids died after five weeks. Seventy-three of the infected pacol seedlings also died during the same period.

TABLE 1.—*Degree of vascular infection of the plants*

VARIETY	NUMBER OF PLANTS INOCULATED	NUMBER OF PLANTS INFECTED	NUMBER OF PLANTS RECOVERED	PERCENTAGE OF MORTALITY
Bongolanon	26	24	2	92
Bulaoluna × Magsarapong	24	16	8	67
Camarahon	25	18	7	72
Canton	7	0	7	0
Experiment Station No. 3	70	55	15	78
Iñosa	12	8	4	67
Kurisan × Magsarapong	24	19	5	79
Maguindanao	25	19	6	76
Musa lolodensis	96	96	0	100
Magsarapong × Inisarog	16	12	4	75
Pacol	84	73	11	87
Putian × Kurisan	12	8	4	67
Putian × Magsarapong	5	4	1	80
Pacol × abacá	10	10	0	100
Tangongon	102	90	12	88
Ugaram × Magsarapong	40	29	11	72

On Bongolanon, Camarahon, Tangongon, and Inosa, signs of wilting of the lower leaves were observed after four weeks. Ten seedlings of Bongolanon, 8 of Camarahon, 26 of Tangongon, and 4 of Inosa were infected. A week later, all the abacá seedlings showed wilting.

All the intervarietal crosses of abacá showed wilting after two months. Two weeks later the following seedlings died: 16 of Bulaoluna x Magsarapong, 19 of Kurisan x Magsarapong, 12 of Magsarapong x Inisarog, 8 of Putian x Kurisan, 4 of Putian x Magsarapong, 29 of Ugaram x Magsarapong, and 19 of Maguindanao.

Experiment Station No. 3 seedlings showed wilting after three months; two weeks later, 55 seedlings died from the infection. In all cases none of the control plants were infected.

Microscopic examinations of the roots and corms of the dead plants showed reddish vascular bundles and rot of varying degrees of severity. Isolations made from the diseased corms yielded a species of *Fusarium* similar to the original isolations.

In canton, no sign of wilting or stunting was noted even after eight months. Although reinoculations were made at two-month intervals, no difference was observed between the inoculated and the control plants. Isolations made from the corms and microscopic examinations showed no species of *Fusarium*.

According to Ocfemia and Palo (1926) and Castillo and Celino (1940), the banana varieties resistant to wilt are Lacatan (*M. sapientum* L. var. *lacatan* [Blanco] Teodoro), Buñgulan (*M. sapientum* L. var. *suaveolens* [Blanco] Teodoro), Gloria or Ternate (*M. sapientum* L. var. *ternatensis* [Blanco] Teodoro), and Saba (*M. sapientum* L. var. *compressa* [Blanco] Teodoro).

In addition to the fact that the degree of infection decreased as older seedlings were used, many of the fast-growing plants outgrew the disease and in time recovered completely from it. These results are in accord with the observations of Leoncio and Permar of the United Fruit Company of the Republic of Panama (Castillo and Celino, 1940).

The apparent severity of the disease on young seedlings may be attributed to the fact that their corms and young roots are more or less tender and are more easily penetrated by the fungus.

The results indicate that in breeding for resistance to abacá wilt, canton may be used as a source of resistance. Further studies should be done to determine whether or not the resistance to wilt of canton is a dominant factor.

RECOMMENDATIONS FOR CONTROL

1. Since the causal organism is found in the soil and in diseased plants, planting materials should not be taken from infected plantations. The sporadic presence of the disease in infected plantations shows that even seemingly healthy plants are not safe to use.

2. Since the disease can be transmitted mechanically, tools which have been used in cutting diseased plants should be properly disinfected before they are used on healthy stalks.

3. If possible, diseased plants or hills should be totally destroyed and the surrounding grounds disinfected by burning or by the use of chemicals.

4. Diseased plants should be properly disposed of and not allowed to rot in the plantation. Diseased stalks should not be stripped in the plantation.

5. Since excess water in the soil is conducive to the development of the disease, water-logged plantations should be drained. Well-drained soil provides better aeration and promotes the development of a strong root system.

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No biologist can work intelligently or hope to discover even a shred of the laws governing living things if he does not thoroughly apply physical and chemical knowledge, methods and principles, to the extent that a modern biological laboratory is hardly distinguishable in appearance from a laboratory of physics or chemistry.

—*Ludwig von Bertallanffy*

MECHANICAL TRANSMISSION OF THE ABACÁ MOSAIC VIRUS [1]

M. S. Celino and Aureo L. Martinez [2]

WITH ONE TEXT FIGURE AND ONE PLATE

With the aid of carborundum 320, abacá mosaic virus was communicated to healthy abacá, arrowroot, corn, and *Canna indica* seedlings. Although only a small number of the plants inoculated showed mosaic infection, this result constitutes a direct evidence of the sap inoculability of mosaic of abacá.

Positive transmission of abacá mosaic virus by manual means shows that the process of virus transfer by the aphid vectors from mosaicked abacá to susceptible plants is entirely mechanical. In the field, mosaic of abacá is spread mainly by aphids which can carry the virus in their mouth parts. Abacá mosaic virus is in the category of aphid-borne nonpersistent viruses.

The failure of abacá mosaic virus to infect bananas may be due to virus-host incompatibility.

Earlier attempts to transmit a severe form of abacá mosaic by sap injection, pinpricks, and leaf contact yielded negative results (Celino, 1940). In 1938 Ocfemia and Celino obtained mosaic infection by leaf contact in one out of 16 abacá plants used in transmission experiments. However, this result was not considered conclusive because the percentage of infection was low. Moreover, such a result was not confirmed in subsequent trials. Juliano (1951) similarly reported failure to transmit abacá mosaic virus to abacá by the crushed tissue method, insertion of diseased tissues, and grafting, besides sap injection and needlepricks.

Little progress had been attained in the transmission of abacá mosaic by manual means when in 1955 a strain of virus was isolated from mosaicked abacá and successfully communicated to corn seedlings by needlepricks. In retransmission tests, however, this virus induced in abacá plants a mild form of mosaic. It is not therefore regarded as related to, or identical with, the strain of mosaic virus

[1] Central Experiment Station Contribution No. 1899.

[2] The writers thank Dr. F. T. Orillo, acting head of the Department of Plant Pathology, Dr. G. O. Ocfemia, professor of plant pathology, and Dr. C. S. Reddy, visiting Cornell professor, for valuable suggestions on the manuscript.

which causes the destructive and severe type of mottling in abacá (Celino and Martinez, 1955).

It has been found in insect transmission studies of abacá mosaic that *Rhopalosiphum nympheae* can acquire the virus in short feeding periods. Such virus is infectious immediately after it has been drawn out by the aphid vector from the tissues of mosaicked abacá. All of it, however, is lost when the insect feeds on a healthy abacá plant for two hours. These characteristics of abacá mosaic virus are similar to those commonly manifested by nonpersistent viruses (Leach, 1940; Watson, 1938, 1946; Kassanis, 1941; Hamlyn, 1953; Maramorosch, 1954; Sylvester, 1954) which are generally believed to be mechanically transmitted (Doolittle and Walker, 1928; Hoggan, 1933; Bradley, 1952; Sylvester, 1954).

It is believed that abacá mosaic virus in the Philippines is transmitted by its animal vectors in a mechanical manner. Direct proof, however, is lacking to support this view, hence this study.

TRANSMISSION OF ABACÁ MOSAIC VIRUS BY THE LEAF EDGE-CARBORUNDUM METHOD

Transmission to abacá. From December, 1955, to June, 1956, the writers attempted to transmit abacá mosaic virus with the aid of carborundum 320. Carborundum was dusted thinly on the upper surface of newly expanded leaves of healthy abacá seedlings which were grown from seeds in the greenhouse. Then a partly emerged and still tightly folded leaf of an abacá seedling infected with mosaic was cut with a Gillette blade, and the newly cut edge was drawn back and forth with a little pressure against the carborundum-dusted leaves of experimental abacá plants. The leaf was supported with one hand as it was being inoculated to prevent it from breaking or tearing apart (fig. 1). Fresh leaf edge was used by cutting back the folded infected leaf. After inoculation the plants were placed for observation in the greenhouse away from mosaicked abacá and insects. Plants treated similarly with healthy abacá leaves were kept as control in the greenhouse during the experiment.

Of 16 abacá seedlings inoculated on December 24, 1955, four developed mosaic disease with brilliant mottling on the leaves (Plate I, fig. 1). The respective incubation periods were 14, 21, 33, and 44 days.

Of six abacá seedlings inoculated on January 16 and six others on February 10 and 18, 1956, only one plant became infected after an incubation period of 25 days.

Fig. 1.—Abacá seedlings and other experimental plants were inoculated with abacá mosaic virus by dusting thinly the upper surface of an expanded leaf with carborundum 320 and then rubbing it gently with a freshly cut end of a tightly folded leaf of a diseased abacá plant. (*Photographed by the Photographic Division, College of Agriculture*).

Of seven abacá seedlings treated on March 19 and 21, 1956, three plants showed mosaic infection with a range in incubation period of 12 to 37 days. In a replicate experiment on March 26 which involved 14 abacá seedlings, only two plants became diseased, one after an incubation period of 10 days and the other, 21 days. In no instance did mosaic disease appear on any of the check plants in all the experiments.

Transmission to arrowroot (*Marantha arundinacea*). In insect transmission studies of abacá mosaic, the writers obtained successful transfer of virus from diseased abacá to healthy arrowroot plants. Since arrowroot is susceptible to abacá mosaic virus, this plant was used as suscept in transmission studies by the leaf edge-carborundum method.

From January 31 to February 17, 1956, seven healthy and young arrowroot plants grown from rhizomes were inoculated as in the previous experiments. Healthy arrowroot plants treated with ino-

culum from healthy abacá served as control. Three experimental arrowroot plants showed mosaic disease after respective incubation periods of 10, 15, and 16 days.

From March 19 to April 6, 1956, twenty-eight arrowroot plants were used in a transmission experiment similar to the preceding ones. Eleven showed mosaic infection in 12 to 20 days.

Three arrowroot plants were inoculated on April 10, 1956, by rubbing the inoculum on the nether surface of the leaves instead of on the upper side. This trial resulted in symptoms in one plant after two weeks. All check plants in all tests remained healthy throughout.

From artificially infected arrowroot, the virus was recovered by aphid vectors and communicated back to healthy abacá seedlings where it reproduced itself readily, as indicated by the intense mottling on the leaves.

The earliest symptoms induced by abacá mosaic virus on arrowroot plants in artificial infection experiments consist of white or pale white short, fine, but clearly discernible lines which appear on young unfolding leaves about two to three weeks after inoculation. These white fine lines run parallel to each other, but they are almost perpendicular to the leaf veins (Plate I, fig. 2). The veins of the leaf seem to restrict the length of these lines. As more of these lines appear in subsequent leaves, they form ladderlike arrangements with the leaf veins. These lines persist even after the formation of the characteristic mosaic pattern.

Bright mottling manifests itself on subsequent leaves. At first this mottling consists of a few elongate yellow areas or patches with wavy outlines more or less, and they follow the direction of the veins. With the formation of more leaves these yellowish patches appear in greater intensity and in different sizes. A few long ones may extend from the midrib to about the margin of the leaf. These yellowish patches, together with the green areas of the leaf, produce the characteristic mottling appearance of a severe mosaic infection. With age, or in advanced infection, the mosaic pattern appears also at the base of the petioles of the leaves and on the upper parts of the leaf sheaths. These symptoms of artificially infected arrowroot plants appear similar to the mosaic patterns described on leaves of diseased abacá and *C. indica* in Mindanao.

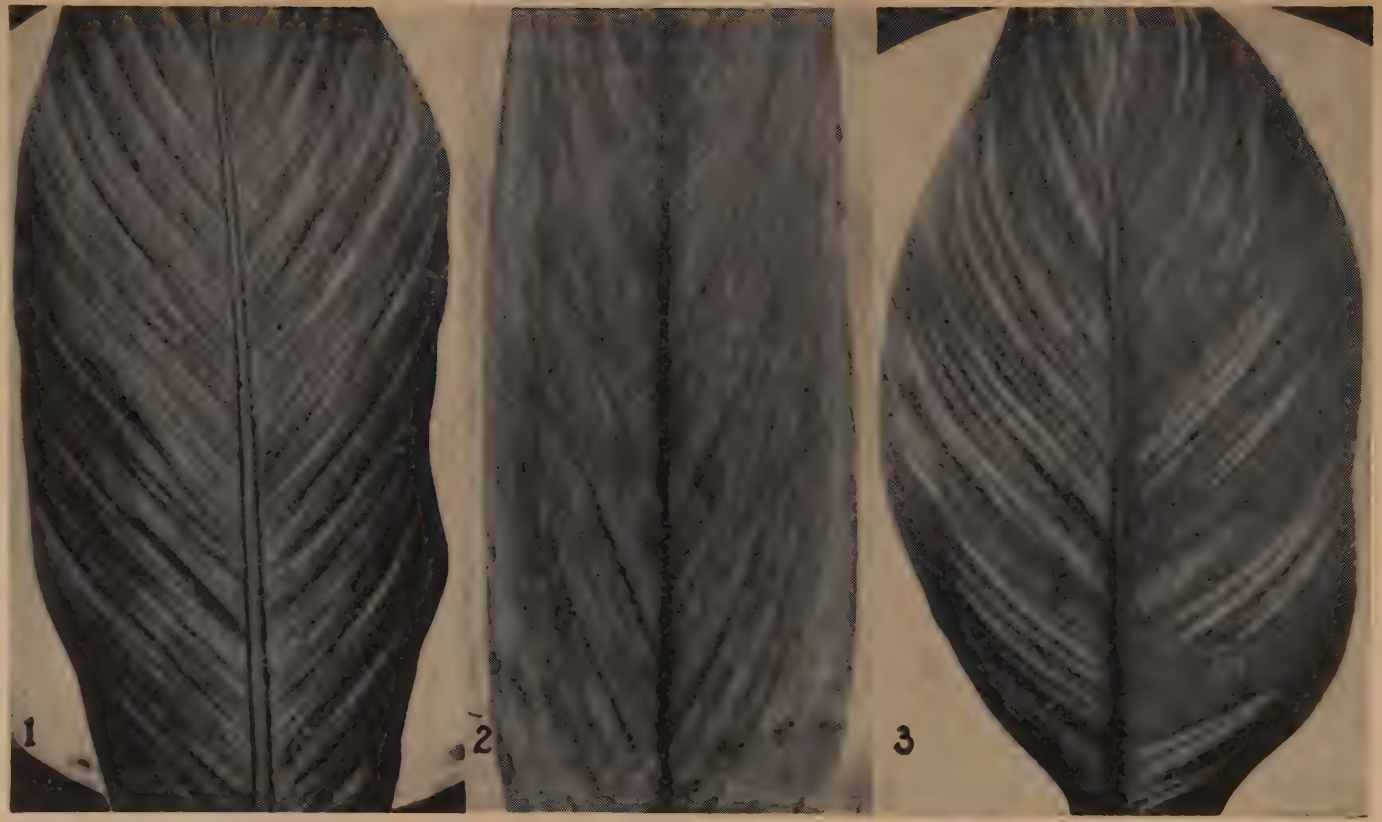
Transmission to Canna indica. Inoculation of abacá mosaic virus to *C. indica* seedlings by the leaf edge method resulted also in

mosaic symptoms. Of 23 *C. indica* seedlings treated at different times from April 18 to May 11, 1956, four showed mosaic disease in 34 to 40 days. Infection of *C. indica* is to be expected as this plant has been shown in previous insect transmission experiments to be susceptible to abacá mosaic virus. The symptoms induced in *Canna* by the leaf edge method appear similar to those produced in this plant by the same virus in insect transmission experiments and also to those observed in *C. indica* naturally infected with mosaic in Davao.

The earliest discernible symptoms of infection consist of small white dots on partially expanded leaves of *C. indica* seedling 34 to 40 days after inoculation. These dots are about the size of a pinhead and are located between the leaf veins. Circular at first, they develop later into short dashes which tend to connect two parallel veins. Each dash or line therefore lies more or less perpendicular to the veins which seem to restrict or limit its ends. Later, as more leaves are formed by the plants, small spindle-shaped yellowish patches appear. These yellowish patches are scattered on the lamina of the leaf and lie in the direction of the veins. They are of different sizes. Some are long and extend from the midrib to near the margin of the leaf. Between these yellowish patches are green areas, and together they produce the mottling effect (Plate I, fig. 3). In advanced stages of infection puckering or wrinkling of leaves occurs. The leaf surface then becomes uneven and curled in places. Mottling develops also on the leaf sheaths and on flower parts. With age the chlorotic areas in the leaves turn brown to rusty brown and the tissues gradually die and dry out.

These symptoms are very similar to those of *C. indica* mosaic in Davao. Mosaic of *C. indica* produces irregular pale yellow stripes parallel to the veins of the leaves. The stripes may extend from the midrib to the margin of the leaves. The leaves are more or less wrinkled and curled. The chlorotic areas turn rusty brown. Symptoms may be noted also on stems, sepals, and petals of flowers. Mottling of the fruit is not as distinct as that of the leaves. *Canna indica* mosaic is transmissible to abacá seedlings by *Aphis gossypii* and *A. maidis* (Ocfemia, Macaspac, and Hsieh, 1941).

Brierley and Smith (1948) consider mosaic of *Canna* in the United States the same as the mosaic of *C. indica* previously reported from the Philippines. They also obtained transmissions by *A. gossypii* and *A. maidis*. The principal discrepancy, however, is the



Celino and Martinez: Mechanical Transmission of the Abacá Mosaic Virus

Fig. 1. An expanded abacá leaf inoculated with abacá mosaic by the leaf edge-carborundum method. Note the intense mottling.

Fig. 2. A portion of an arrowroot leaf (*Maranta arundinacea*) artificially infected with abacá mosaic virus by manual means.

Fig. 3. An expanded leaf of *Canna indica* showing advanced symptoms of mosaic disease induced by abacá mosaic virus in mechanical transmission experiment. (*Photographed by the Photographic Division, College of Agriculture*).

failure of *Canna* mosaic in the United States to infect *Musa textilis*. Castillo, Yarwood, and Gold (1956), who studied mosaic of *Canna generalis* in the San Francisco Bay area of California, regard the causal virus as possibly identical with a strain of abacá mosaic virus and yellow bean mosaic virus. Castillo, who has seen infection of abacá mosaic virus in *Canna* in the Philippines and natural mosaic infection in *Canna* in California, believes that the two diseases look alike. In their transmission studies, however, the virus of *Canna* mosaic in California did not infect arrowroot (*Marantha arundinacea*), a plant which is highly susceptible to virus of abacá mosaic and *Canna indica* mosaic in the Philippines.

Transmission to corn. Inoculation of young corn seedlings by mechanical means resulted in systemic mosaic infection. Mild form of mottling was induced in these plants. From corn the virus was recovered by aphids and in retransmission tests produced mosaic with intense mottling in abacá seedlings. These results tend to show that abacá mosaic virus is not attenuated by passage through corn. Corn can therefore harbor abacá mosaic whenever this plant is grown side by side with mosaicked abacá. Reinking points out that corn plantings are a great factor in the spread of mosaic disease.[3] Failure to control abacá mosaic in the entire Kidapawan area was attributed to the universal planting of corn with abacá by small farmers.

Failure of transmission to Cavendish banana. Different varieties of Philippine bananas have not been infected with abacá mosaic virus in insect transmission experiments (Celino, 1940; Juliano, 1951). Repeated inoculations with either *A. maidis* or *A. gossypii* as vector failed also to induce abacá mosaic in Cavendish banana (*Musa cavendishii* Lambert). From January to June, 1956, six potted Cavendish plants were inoculated with abacá mosaic virus by the leaf edge-carborundum method. Each of six successive leaves which unfurled on each plant was inoculated, but in spite of repeated inoculations mosaic did not appear in any of the Cavendish bananas.

Failure of abacá mosaic virus to infect Cavendish banana may be attributed to its inability to establish itself and multiply in the cell protoplasm of this plant. All artificially inoculated Cavendish bananas used as virus source in insect transmission experiments did not cause mosaic infection in any of susceptible abacá seedlings.

[3] O. A. Reinking, "Review of Abacá Mosaic Control Program in the Philippines, 1954-1955," United States of America Operations Mission to the Philippines, Agriculture Division, Manila, February, 1955, 34 pp.

DISCUSSION OF RESULTS

Experimental results show that abacá mosaic disease is sap inoculable. With the aid of carborundum the mosaic virus was communicated to abacá, arrowroot, corn, and *Canna indica* seedlings. Earlier workers failed to transmit the virus by needle pricks, sap injection, leaf contact, use of crushed tissues, insertion of diseased materials, and other similar methods.

The percentage of infection obtained in the experiments was low. This means that mechanical method is of little significance in the spread of this disease. The result, however, emphasizes an existing fact, that under natural conditions obtaining in the field abacá mosaic is spread mainly by its animal vectors which can carry the virus in their mouth parts.

The present study yields significant information regarding the mechanics of virus transfer. It appears from the results obtained that insect transfer of abacá mosaic virus is entirely mechanical. In this respect abacá mosaic virus is probably in the same category as cucumber mosaic virus (Doolittle and Walker, 1928; Hoggan, 1933), henbane mosaic virus or Hyoscyamus virus strain 3 (Bradley, 1952), Western celery mosaic virus (Severin and Freitag, 1938), potato A virus (MacLachlan, Larson, and Walker, 1953), leathery mottle virus of sweet potato (Webb and Larson, 1954), and a number of other aphid-borne nonpersistent viruses. According to Sylvester (1954), transmission of this group of viruses by aphid vectors is in essence mechanical.

Consistent failure of abacá mosaic virus to infect bananas in insect transmission experiments and by direct inoculation of virus through various manual means is presumably traceable to the existence of virus-host plant incompatibility.

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Without the general intellectual curiosity which characterizes the philosopher as well as the pure scientist, no research would be pursued beyond the point where it closes to pay cash dividends of immediate usefulness. Mankind would become a race of economic monsters, restlessly driving hard bargains with nature and with one another—a consequence feared by Dewey and yet stimulated by his very philosophy.

—*Alfred Stern*

SIX COMBINATION SPRAYS IN THE CONTROL OF INSECT PESTS AND DISEASES OF CACAO [1]

G. B. Viado, F. T. Orillo, D. G. Basio, and R. B. Valdez [2]

Against the pod borer, *Pachyrrhynchus moniliferus*, all treatments except toxaphene + dithane Z-78 gave good control. Control of *Helopeltis bakeri* was obtained with all the treatments, EPN + dithane Z-78 and toxaphene + dithane Z-78 being the best, followed by dieldrin + bordeaux.

For disease control, no significant differences were obtained among the spray combinations tested. However, DDT + dithane Z-78 and EPN + dithane Z-78 seemed to be promising against black rot (*Phytophthora palmivora*). Dithane Z-78 combined with DDT or dieldrin or EPN proved to be very effective against charcoal pod rot (*Botryodiplodia theobromae*).

Cacao growers in the Philippines depend largely upon clean culture and sanitation in controlling insect pests and diseases of cacao. In Indonesia, Van der Knaap (1955) reported that for over 50 years prior to the appearance of the new insecticides, stripping cacao trees of all their pods once a year had been a standard control measure against the cacao pod borer, *Acrocercops cramerella*. This method, although effective, is very expensive. The appearance of new insecticides and fungicides opened a new field in the study of economical and more effective control of insect pests and diseases of cacao. Six of the new insecticide-fungicide combination sprays were tested against insect pests and diseases of cacao in the cacao plantation of the College from June, 1955, to March, 1956.

MATERIALS AND METHODS

The combination sprays tested were: DDT + dithane Z-78, dieldrin + dithane Z-78, EPN + dithane Z-78, toxaphene + dithane Z-78, dieldrin + bordeaux, and dieldrin + orthocide 50.

The amounts of insecticides and fungicides used per 100 gallons of water were as follows:

25% DDT emulsifiable concentrate	2 quarts
50% dieldrin wettable powder	1 pound

[1] Central Experiment Station Contribution No. 1900. Coffee and Cacao Development Project.

[2] The authors acknowledge the help of Drs. J. G. Matthysse and A. G. Newhall, former Cornell visiting professors, in planning and conducting this experiment.

25% EPN wettable powder	2 pounds
40% toxaphene wettable powder	4 pounds
65% dithane Z–78	2 pounds
Bordeaux mixture	4–4–50 formulation [3]
50% orthocide 50	2 pounds

Sticker (Macondray No. 78) was used with dithane Z-78 at the rate of 240 ml. per 100 gallons water.

The experiment was divided into four randomized blocks, each consisting of six treated plots and a control. The number of bearing trees in a plot varied from five to six. Spraying was done at two-week intervals with a 25-gallon "Hardie" single-nozzle power sprayer which operated at a pressure of 200 to 300 psi. The first spraying was done on June 17, 1955, when the trees were beginning to flower, and the last spraying on December 9, 1955, when the smallest pods were about an inch in diameter.

DISCUSSION OF RESULTS

Insects and diseases that affected the pods. Prespraying observation showed that only two species of insects, *Helopeltis bakeri* and *Pachyrrhynchus moniliferus*, were causing serious damage to the plants. The moth borer of cacao pod, *Acrocercops cramerella*, and another species of capsid, *Helopeltis* sp. (probably *collaris*), were also observed on the pods, but they were few and caused negligible damage. The larva of *Pachyrrhynchus moniliferus* caused more serious injury than the capsid bugs. Only a few cases of injury by this insect on the bark were noted at the start of the experiment. Most of the injury was on the pods. The adult was found feeding on the young leaves of cacao.

The tiny moth borer of cacao pod, *Acrocercops cramerella*, although of widespread distribution in the Philippines, attacked only a few almost mature pods at the start of the experiment. The damage on the pods was not as extensive as that caused by the *Pachyrrhynchid* borer.

At the start of the experiment black pod rot (*Phytophthora palmivora*) and charcoal pod rot (*Botryodiplodia theobromae*) were observed on several trees. Black pod rot was present on pods that were of the size of the thumb or bigger.

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[3] Used in the first two spray applications. In the last nine applications, 2-2-50 Bordeaux mixture was used.

Effect on Pachyrrhynchid borer. The best combination against *Pachyrrhynchus moniliferus* was dieldrin + bordeaux, followed by EPN + dithane Z-78, dieldrin + dithane Z-78, DDT + dithane Z-78, and dieldrin + orthocide 50 (table 1). All the treatments except toxaphene + dithane Z-78 showed significant control of the borer. The borer infestation on the trees treated with toxaphene + dithane Z-78 was higher than that on the control trees. The insect repellent action of Bordeaux mixture may account partly for the fact that dieldrin + bordeaux was slightly better than dieldrin + dithane Z-78 and much better than dieldrin + orthocide 50.

TABLE 1.—*Percentage of pods infested by Pachyrrhynchid pod borer in plots sprayed with six combination sprays*

TREATMENT	REPLICATION				MEAN	COMPUTED MEAN [a]
	I	II	III	IV		
DDT + dithane	0.00	1.71	1.83	1.32	1.22	5.44
Dieldrin + dithane	0.41	0.00	2.80	1.15	1.09	5.07
EPN + dithane	0.00	2.26	0.00	1.80	1.01	4.12
Toxaphene + dithane	10.58	26.92	60.00	11.86	27.34	30.25
Dieldrin + bordeaux	3.45	0.00	0.00	0.30	0.94	3.48
Dieldrin + orthocide	0.00	8.47	1.44	2.53	3.11	8.21
Control	21.28	22.22	33.33	7.55	21.09	26.68
Total	35.72	61.58	99.40	26.51		

[a] Mean of the computed transformed angles of percentages.
S.M.D. (T) at 5% = 4.53
1% = 6.21

Effect on capsid bugs. Against capsid bugs EPN + dithane Z-78 was the best, followed by toxaphene + dithane Z-78, dieldrin + bordeaux, DDT + dithane Z-78, and dieldrin + dithane Z-78 (table 2). The combination which gave the poorest control was dieldrin + orthocide 50. Nevertheless, it also gave significant control of the bugs.

Urquhart (1955) recommended painting young cacao trees with 2.5 per cent DDT emulsion to protect them from severe attack of capsid bugs. He stated that DDT emulsion possesses considerable residual toxicity, lasting from four to five months. In the Gold Coast, Taylor (1954) reported that against capsid bugs on cacao, DDT dusting was the best. Nicol and Taylor (1955) later observed that a monthly application of 2.3 per cent gamma BHC dust also gave good reduction of capsid infestation. In the present study, DDT + dithane Z-78 gave good control of *Helopeltis*, but it was

TABLE 2.—*Percentage of pods injured by Helopeltis in plots sprayed with six combination sprays*

TREATMENT	REPLICATION				MEAN	COMPUTED MEAN [a]
	I	II	III	IV		
DDT + dithane	12.70	22.22	10.09	21.05	16.52	23.70
Dieldrin + dithane	6.56	23.47	17.76	40.23	22.01	27.02
EPN + dithane	6.18	6.33	1.45	4.50	4.62	12.00
Toxaphene + dithane	8.65	6.41	10.00	0.00	6.27	12.53
Dieldrin + bordeaux	36.21	0.00	4.92	10.67	12.95	17.22
Dieldrin + orthocide	32.83	57.63	25.90	50.63	41.75	40.06
Control	47.87	84.13	75.00	63.21	67.55	55.74
Total	151.00	200.19	145.12	190.29		

[a] Mean of the computed transformed angles of percentages.
S.M.D. (T) at 5% = 4.78
1% = 6.55

inferior to either EPN + dithane Z-78 or toxaphene + dithane Z-78. Laoh (1954) reported that 16 applications a year of endrin at 300 cc. per 200 liters water per hectare satisfactorily controlled pod borer and *Helopeltis* bugs, but that DDT, BHC, and dieldrin were ineffective in both laboratory and field tests. In 1955, he reported that knapsack sprayers gave poorer coverage than power sprayers.

Effect on pod moth borer. The very low incidence of the pod moth borer invalidated the test on the effect of the various spray combinations on this insect. However, no pod on any of the treated trees was infested by this insect throughout the experiment.

Effect on diseases. The different spray combinations did not differ significantly in the degree of control of black pod rot (*Phytophthora palmivora*) and charcoal pod rot (*Botryodiplodia theobromae*). However, DDT + dithane Z-78 and EPN + dithane Z-78 seemed to be promising against *Phytophthora* infection. The plot sprayed with DDT + dithane gave only 1.52 per cent infection, and that sprayed with EPN + dithane, 1.90 per cent. Dithane Z-78 combined with DDT or dieldrin or EPN appeared to be very effective against *Botryodiplodia* infection. The plots sprayed with these combinations yielded pods that did not show any damage by the *Botryodiplodia* fungus.

It is reported that dithane Z-78 applied at 7- and 14-day intervals is almost as effective as Bordeaux mixture at 30-day cycle (Anonymous, 1953). Experiments in Costa Rica showed that Bordeaux mixture sprayed at 30- and 60-day intervals gave better control than

dithane Z-78 or orthocide and that bordeaux and dithane Z-78 applied at 30-day interval increased production 40 per cent over the check and orthocide treatments (Anonymous, 1954).

The writers observed that in the plots sprayed with toxaphene + dithane Z-78, the incidence of the two types of pod rot was higher than that in the check. It is probable that the pod borer injury in these plots accelerated fungus infection and made them worse than the check.

Herbicidal effect of the spray combinations. The dieldrin + dithane Z-78 combination was the only treatment which had a burning effect on the young leaves. The injury, however, was not serious, and the affected leaves recovered.

Effect on wild cats. None of the treatments proved a deterrent to wild cats. These animals are a problem in plantations near forests where they are present. They make a hole on the sides of almost mature and mature pods and feed on the sweet glutinous covering of the seed. The empty pod is left on the tree.

Yield. The yield was based on the number of mature pods harvested, including those damaged by wild cats. Analysis of the yield results shows that only the plots treated with dieldrin + dithane Z-78 and DDT + dithane Z-78 yielded significantly more than the control (table 3). The plot sprayed with toxaphene + dithane Z-78 gave only 12.7 pods, which was even lower than the yield of the control. On the basis of yield of sound pods no significant differences were found among the various treatments. The highest percentages of sound pods were given by the dieldrin + combinations, which were only slightly higher than that of the control.

TABLE 3.—*Average number of harvested pods to a tree in the different plots*

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
DDT + dithane	21.00	23.40	21.80	32.57	98.77	24.7
Dieldrin + dithane	34.86	24.50	13.37	43.50	116.23	29.1
EPN + dithane	24.25	31.57	17.25	22.20	95.27	23.8
Toxaphene + dithane	20.80	13.00	5.00	11.80	50.60	12.7
Dieldrin + bordeaux	11.60	11.33	15.25	41.00	79.18	19.8
Dieldrin + orthocide	13.40	19.67	23.17	26.33	82.57	20.6
Control	11.75	10.50	9.60	21.20	53.05	13.3
Total	137.66	133.97	105.44	198.60	575.67	

S.M.D. (T) at 5% = 10.72.

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Research is the manipulation of things, concepts or symbols for the purpose of generalizing to extend, correct or verify knowledge, whether that knowledge aid in the construction of a theory or in the practice of an art.

—*Encyclopedia of the Social Sciences*

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For a university rightly and inherently is a place where the individual man can form new syntheses, where the accidents of friendship and association can open a man's eyes to a part of science or art which he had not known before, where parts of human life, remote and perhaps superficially incompatible, can find in men their harmony and their syntheses.

—*J. Robert Oppenheimer*

TREATMENT OF INFECTIOUS CORYZA OF CHICKENS WITH TERRAMYCIN [1]

FRANK P. DINSAY III

WITH TWO TEXT FIGURES

Quicker relief was afforded by terramycin in redistilled water than by terramycin in mineral oil. Response was faster when the treatment was given early. Terramycin in mineral oil had a longer curative effect.

Several preparations for treating infectious coryza or roup have been tried with varying degrees of success. Respiratory inhalants (Kaupp and Surface, 1950), antiroup vaccine,[2] sulfathiazole, and dilute solutions of mercuric chloride (Blount, 1947) have been tried, as well as penicillin and streptomycin among the antibiotics. Terramycin (oxytetracycline) therapy was recently introduced with encouraging results.

Peterson (1952) found that birds with blue comb respond within 24 hours to terramycin given during the early stage of disease. Carson *et al.* (1953) reported that pullets with chronic respiratory disease appeared cured after being injected with 50 mg. of terramycin in oil suspension. Wong and James (1953) found terramycin and magnamycin to be most effective in the treatment of chronic respiratory diseases. Bowers (1954) also stated that pullets with coryza responded after one week of treatment with 4 cc. of a suspension of terramycin in oil.

This study was conducted from June, 1954, to May, 1955, to find out the effect locally of terramycin injection on chickens with infectious coryza.

MATERIALS AND METHODS

Four hundred eighty two- to three-month-old S. C. White Leghorn weanlings with natural infections were grouped at random into four lots of ten males and ten females each. In one set of ex-

[1] Central Experiment Station Contribution No. 1901. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, October, 1955. Prepared in the Department of Animal Husbandry under the direction of Assistant Professors Gonzalo V. Garcia and Amado C. Campos.

[2] F. M. FRONDA and F. S. MENSALVAS, *Agric. Indus. Life,* (3), 13: 6 (1951).

periments, the birds were injected with a suspension of 90 mg. of crystalline terramycin hydrochloride [3] in 90 ml. albolene oil; in another set, with terramycin dissolved in 90 ml. of redistilled water.

Both mixtures were administered hypodermically at the back of the bird's head just below the comb. In the first set, lot II was given six 1-cc. doses of terramycin in oil; lot III, six 1.5-cc. doses; and lot IV, six 2-cc. doses. The doses were given every other day to allow time for the absorption of the oil suspension. The redistilled water solution, on the other hand, was administered daily.

The birds in both sets received the same care. They were examined daily for the disappearance of symptoms. Birds in which the visible symptoms had disappeared were not separated from the rest to find out whether apparently recovered birds would develop resistance or immunity to the disease.

RESULTS AND DISCUSSION

Terramycin administered in oil suspension

Disappearance of symptoms. One day after the first treatment with terramycin, 31 per cent of the birds in lot II, 37 per cent in lot III, and 47 per cent in lot IV showed dried-up nostrils. All the birds in lot I (control) still had nasal discharges. Before the 12-day injection period ended, 79 per cent of the birds in lot II, 77 per cent in lot III, and 82 per cent in lot IV had apparently recovered. Because of reinfection or incomplete recovery, however, slightly fewer birds recovered at the end of the 40-day observation period than during the period of injection (fig. 1).

Reinfection. After the sixth injection, a number of the apparently cured birds in the experimental lots showed alternating signs of reinfection and recovery. Some birds were reinfected as often as four to five times during the observation period. All the control birds, on the other hand, continued to have nasal discharges until after the end of the second week of the study, when some showed signs of recovery possibly because of increased resistance or immunity. It was also noted that birds treated early responded faster than those treated at a later stage of the infection. This might have been due to complications in the birds.

Mortality. Mortality in the control lots was greater than in the experimental lots. The control lot of trial 1 had 60 per cent

[3] Furnished partly by the local representative of the Chas. Pfizer Co. of New York.

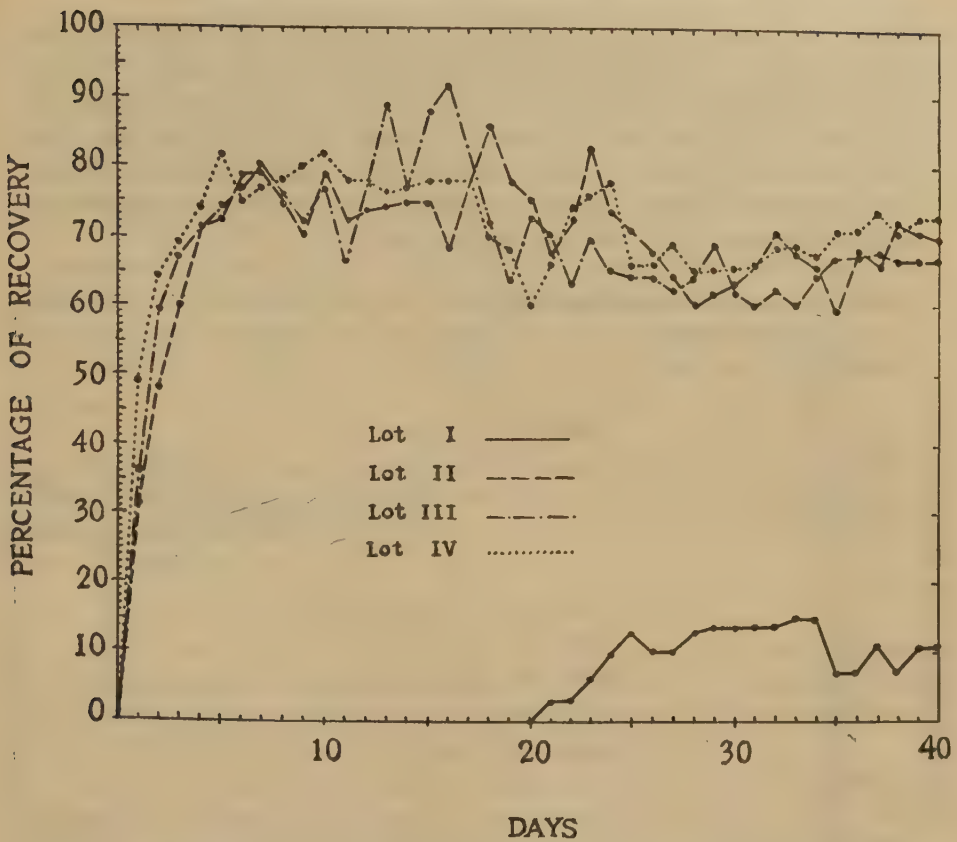

Fig. 1.—Percentage of birds that recovered after treatment with terramycin in oil.

mortality; that of trial 2, 55 per cent: and that of trial 3, 40 per cent. The average mortality of lot I in the three trials was 52 per cent; among the experimental lots, the average was 28 per cent for lot II, 22 per cent for lot III, and 25 per cent for lot IV. The greatest mortality in all the lots occurred during the first and second weeks of the experiment. The possible reason for this is that the oil suspension was not easily absorbed so that the antibiotic did not act immediately.

Terramycin administered in redistilled water solution

Disappearance of symptoms. Symptoms disappeared in proportionally more birds after the first day of treatment with a solution of terramycin in redistilled water. Sixty-nine per cent of the birds in lot II, 93 per cent in lot III, and 76 per cent in lot IV appeared

cured. After the fourth injection, all the birds in lot III and IV appeared cured. Lot II had a recovery of only 92 per cent. The remarkable results obtained may be attributed to the faster action of antibiotic when dissolved in water. Eleven days after the last dose (6th injection), there was a sudden drop in the percentage of apparently cured birds in lots III and IV; on the other hand, symptoms began to disappear in the control lot (fig. 2).

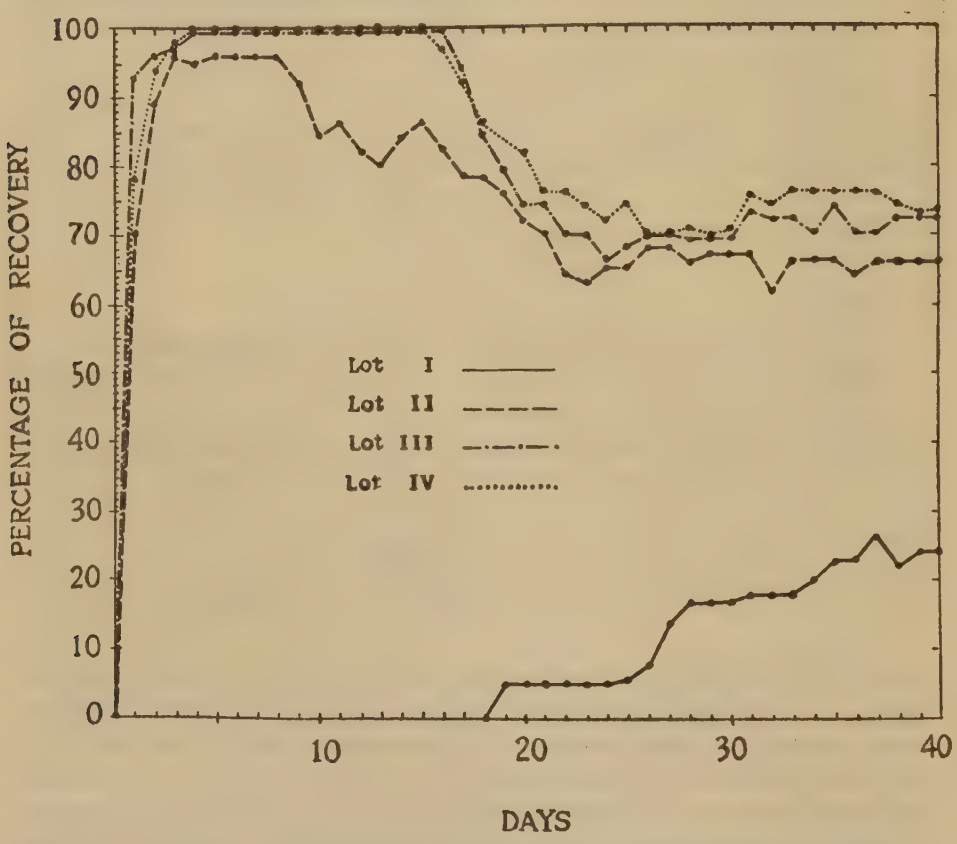

Fig. 2.—Percentage of birds that recovered after treatment with terramycin in redistilled water.

After the ninth day, the percentage of recovery in lot II started to go down and continued to drop until the end of the experiment. The effect of the antibiotic in lot II did not last as long as the effect in lots III and IV apparently because lot II received the smallest dose. However, as in lot II ,there was a reappearance of nasal discharges in some birds in lots III and IV.

Terramycin in water had a shorter curative effect than terramycin in oil. On the average, symptoms reappeared from five to six days after the last injection in the first set and two to three days after in the second set. The birds took a longer time to completely eliminate terramycin in oil.

Mortality. As in set 1, the control lot of set 2 had a high average mortality rate, 48 per cent, as against 12 to 27 per cent in the treated lots. Birds in the control lot did not receive any treatment; therefore, any sign of relief or cure could be attributed to resistance or increasing immunity to the disease. Since the birds were young and had less resistance to diseases, mortality was expected to be great.

POST-MORTEM EXAMINATION

In addition to coryza, some of the birds examined by the College veterinarian were found to be suffering from cecal and intestinal coccidiocis, worm infection, and inflammation of some parts of the respiratory tract.

Individual weights of remaining birds

Statistical analysis showed no significant differences in final weight among the remaining birds in the first set. This was probably due to the stormy weather and to the fact that the birds in this set were unknowingly fed adulterated fish meal.

In set 2, however, the birds which received 1.00-cc. treatment increased in weight significantly over the control. The SMD was 42.76 at 5 per cent and 56.42 at 1 per cent. Those given the 1.50-cc. treatment did not show a significant increase over the birds given 1.00 cc., but the increase was still more significant over that of the control. Those given 2.00 cc. showed an insignificant increase over the control.

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ACCFA CROP AND FARM IMPROVEMENT LOANS GIVEN THROUGH THE FACOMA IN STA. CRUZ, LAGUNA 1953-1954 [1]

TEODORO MENDIOLA ELA

Most of the farmers who borrowed from the ACCFA through the Sta. Cruz Facoma were tenants. Only 9 of the 205 farmers were owner-operators. The lessees had the largest farms and the highest expected production. No apparent relationship was shown by the amount of palay pledged and the loan granted. The owners pledged more (87 per cent) of their expected produce than the other landholders. The tenants pledged only 43 per cent.

The farmers secured farm improvement loans mainly for the purchase of carabaos. Crop loans were obtained mainly for planting. The loans were needed most in August, when 50 per cent of all the loans were obtained. Ninety per cent of all the loans were smaller than ₱600.

Farmers' cooperative marketing associations (Facomas) are business organizations established to carry out the objectives of the Agricultural Credit and Cooperative Financing Administration (ACCFA). This survey was conducted to determine the kind of farmers who obtain loans from the ACCFA through a Facoma and the nature of the loans granted.

Two hundred and five of the loan applications filed with the Mithi Ng Bayan Farmers' Cooperative Marketing Association of Sta. Cruz, Laguna, for the fiscal year 1953-1954 were selected for this study from the ACCFA office in Manila. Applications which did not give the desired information were not considered. Additional information was gathered from the office of the Mithi ng Bayan Facoma.

CHARACTERISTICS OF THE FARMERS

Age. The 205 farmers who secured loans averaged 41 years of age. Their ages ranged from 20 to 79 years (table 1). Only 21 per cent of the farmers were over 50 years old.

Civil status. One hundred eighty-five of the farmers were married, 14 were single, and 6 were widowers.

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[1] Central Experiment Station Contribution No. 1902.

Tenure. Of the 205 farmers, 96 per cent were nonowners and only 4 per cent were owners (table 2). Sixty-eight per cent of the nonowners were tenants.

TABLE 1.—*Distribution of farmers in age ranges*

AGE	NUMBER	PER CENT
21–30	45	22
31–40	68	33
41–50	48	24
51–60	27	13
61–70	13	6
71–80	4	2
Total	205	100

TABLE 2.—*Distribution of farmers according to tenure*

TENURE CLASS	NUMBER	PER CENT
Share tenants	139	68
Tenant-lessees	28	14
Lessees [a]	24	12
Owners	9	4
Lessors	2	1
Owner-tenants	1	[b]
Owner-lessees	1	[b]
Owner-tenant-lessees	1	[b]

[a] Cash tenants.
[b] Less than 1%.

At this point, it should be noted that 47 per cent of the farmers in the Philippines rent all or part of the land they farm. In Laguna where this survey was conducted, tenancy is 45 per cent.[2]

In Sta. Cruz, Laguna, the ACCFA granted loans mostly to tenants. The fact that only 4 per cent of the borrowers were owners suggests that this particular Facoma catered mainly to tenant-operators.

THE FARM BUSINESSES

Size of farm. On the average, the tenants had larger farms than other landholders. The average size of farm for all farmers included in this study was 2.98 hectares. The tenants cultivated 2.99

[2] Philippine Census 1948 figures as compiled by the Department of Agricultural Economics, College of Agriculture, University of the Philippines.

hectares, on the average; the tenant lessees, 2.75 hectares; the lessees, 3.15 hectares; and the owners, 2.94 hectares (table 3).

The average size of farms in the Philippines is 3 hectares; more than half of the farms are less than 2 hectares each.[3] On the average, the farmers in this study operated farms close in size to the national average.

Expected production. All of the farmers raised palay as their major crop. They had an average expected production of 148 cavans per farm and 50 cavans per hectare per year. Per farm, the tenants expected an average production of 152 cavans; tenant-lessees, 115 cavans; lessees, 164 cavans; and owners, 154 cavans (table 3). Per hectare they expected 51, 42, 52, and 52 cavans, respectively On the average, therefore, the lessees expected greater total yields than the other types of farmers.

TABLE 3.—*Average farm area, expected production, pledge, and loans*

TENURE CLASS [a]	HECTARES PER FARM	AVERAGE EXPECTED PRODUCTION		PERCENTAGE PRODUCTION PLEDGED	AVERAGE LOAN
		Per farm	Per hectare		
Tenants	2.99	152	51	43	₱312
Tenant-lessees	2.75	115	42	66	277
Lesees	3.15	164	52	49	329
Owners	2.94	154	52	87	327

[a] Farmers in the other tenure categories were too few to be considered.

The national average yield of palay is about 26 cavans per hectare. On the average, the farmers under study expected a yield about twice that of the national average.

Pledge. The average pledge was 72 cavans per farm, or 48 per cent of the expected produce. Generally, owners pledged more than tenants because they had no one else with whom to share the harvest. In this study, the owners pledged 87 per cent of their expected produce, whereas the tenants pledged only 43 per cent (table 3).

There was no apparent relationship between the amount of palay pledged and the loan granted. While the lessees borrowed the biggest amounts, they were required to pledge less than the other landholders in terms of palay. This seems to indicate that for each given size of loan no corresponding equivalent amount of palay is pledged.

The records did not show clearly the amounts originally applied for. Most of the amounts on the loan blanks were those already approved, the original amounts having been erased.

[3] *Ibid.*

THE LOANS

Amount. A total of ₱63,795 was granted to the 205 farmers of the Mithi ng Bayan Facoma in Sta. Cruz, Laguna, during the fiscal year 1953-1954. The farmers received an average loan of ₱311. The lessees received the largest amount, ₱329 on the average, whereas the tenant-lessees received the least, ₱277.

Farm improvement loans. Generally, farm improvement loans are advances to enable farmers to purchase work animals and farm tools. They are payable in one to three years.

Of the ₱31,875 released as farm improvement loans to the farmers in this study, the tenants received 77 per cent and the owners received only 2 per cent (table 4).

Only 98 of the farmers borrowed for farm improvement. Ninety-four of them purchased carabaos. One farmer borrowed ₱1,750 to buy an irrigation pump and to finance the construction of irrigation canals. Incidentally, this was the largest farm improvement loan released.

Crop loans. These are loan accommodations given to farmers to help finance farm operations, payable after harvest or within a period of nine months.

In this study ₱31,920, or 50 per cent of the total loans, was granted as crop loans. The farmers received, on the average, ₱179 under this type of loan. Of the total crop loans released, the tenants received 59 per cent (table 4), or an average of ₱135. Of the four most important tenure classes the owners obtained the largest loans, ₱238 on the average.

TABLE 4.—*Percentage distribution of crop and farm improvement loans of the different tenure classes*

TENURE CLASS	PERCENTAGE OF TOTAL LOANED	
	Crop loan	Farm improvement loan
Tenants	59	77
Tenant-lessees	14	10
Lessees	16	9
Owners	7	2
Lessors	1	1
Owner-tenants	1	—
Owner-lessees	—	21
Owner-tenant-lessees	2	—

Only one loan amounted to ₱2,000, the biggest amount loaned by the ACCFA.

There was a tendency for tenants to require more farm improvement loans than crop loans (table 4).

Purpose of crop loans. Crop loans were obtained mainly for planting (table 5). Sixty-seven per cent of the money was asked for in August, and 29 per cent in September (table 6). The total for the two months was 96 per cent.

TABLE 5.—*Purpose of crop loans*

PURPOSE	AMOUNT	PER CENT
	pesos	
Planting	11,138	35
Land preparation	7,581	24
Transplanting	7,139	22
Subsistence	4,750	15
Fertilizer	1,312	4
Total	31,920	100

Twenty-four per cent of the crop loan money was used for land preparation (table 5). Of the total amount released for land preparation, 96 per cent was given in July and August (table 6).

TABLE 6.—*Percentage distribution by months of the crop loans for different purposes*

	PLANTING	LAND PREPARATION	TRANS-PLANTING	SUBSISTENCE	FERTILIZER
July	3	45	9	14	9
August	67	51	38	33	28
September	29	4	46	33	53
October	1	—	7	9	10
November	—	—	—	6	—
December	—	—	—	4	—
January	—	—	—	1	—
Total	100	100	100	100	100

Of the total crop loans released, 22 per cent were spent for transplanting (table 5). Eighty-four per cent of the loans for this purpose were asked for in August and September (table 6).

For subsistence, the farmers applied for an amount equivalent to 15 per cent of the total crop loans. Sixty per cent of this amount was obtained in August and September.

Only 4 per cent of the total crop loans were requested for the purchase of fertilizer. This amount was obtained from July to October. Eighty-one per cent was used in August and September.

Time of obtaining loans. The distribution of crop loans by time shows that the greatest need was in August, when 50 per cent of the loans were obtained (table 7).

TABLE 7.—*Distribution of crop loans by month*

MONTH	AMOUNT	PER CENT
	pesos	
July	5,162	16
August	15,987	50
September	9,104	28
October	1,130	4
November	290	1
December	184	[a]
January	64	[a]

[a] Less than 1%.

Size of loans. Ninety-five per cent of all the loans were smaller than ₱600. Ninety-two per cent of the farm improvement and crop loans were below ₱400, but a greater percentage of crop loans were in the ₱200-below range (table 8). On the other hand, in the ₱200-400 range, the farm improvement loans had a greater percentage than the crop loans.

TABLE 8.—*Amount and distribution of loans* [a]

AMOUNT	FARM IMPROVEMENT LOANS		CROP LOANS		TOTAL LOANS	
	Number	Per cent	Number	Per cent	Number	Per cent
₱200–below	6	6	134	75	78	38
₱201–400	84	86	31	17	83	40
₱401–600	6	6	9	5	34	17
₱601–800	1	1	3	2	4	2
₱801–above	1	1	1	1	6	3

[a] Some farmers got both crop and farm improvement loans.

The fact that the farmers obtained loans within the range of ₱50 to ₱600 may indicate (1) that farmers' needs are small, (2) that farmers are afraid they might not be able to pay back larger loans, or (3) that the ACCFA discourages loans of larger amounts.

INFLUENCE OF DIFFERENT SOIL MEDIA ON GROWTH OF RAMBUTAN SEEDLINGS

Uninterrupted growth of rambutan seedlings (*Nephelium lappaceun* L.) is necessary for a high percentage of success in budding. To find which soil medium would insure fast, uninterrupted growth, 50 uniform rambutan seedlings were planted in each of the following growth media: (a) fine river sand, (b) rice straw compost, (c) ordinary garden soil, and (d) mixture of river sand, compost, and ordinary garden soil (1:1:1).

In about 13 weeks, differences in sizes of plants attributable to the medium became marked. Plants in (a) averaged 4.1 cm. tall; those in (b), 5.2 cm.; those in (c), 7.0 cm.; and those in (d), 9.1 cm. The S.M.D. at 1 per cent was 1.55 cm. The superiority of the soil-sand-compost mixture as a growth medium was also reflected by the stem diameter, number of leaves, and general appearance. It was assumed that this superiority was due more to the improved soil texture of the mixture rather than to the other factors like availability of nutrients.

LEON C. PESQUIZA

SEEDBED SPRAYING FOR THE CONTROL OF CERCOSPORA LEAF SPOT OF TOBACCO

Control of Cercospora leaf spot (frog-eye) of tobacco in the seedbeds is important because it is there where this disease and other field infections develop. Four fungicides, Manzate (2 lb./100 gal.), Orthocide (2 lb./100 gal.), Fermate (1.5 lb./100 gal.), and Bordeaux (3 lb./50 gal.), were sprayed on tobacco seedbeds during the dry and wet seasons.

Seven sprayings at weekly intervals in both seasons gave the following results: (1) Manzate and Bordeaux gave better control than Orthocide, (2) seedlings sprayed with Bordeaux and Fermate had darker foliage and stems than the control or any of the other treated seedlings, (3) all treated seedlings grew significantly better than the control, but Orthocide and Bordeaux-sprayed plants showed the best growth, (4) all treated seedlings did not show marked residual effect after transplanting in the field.

FLAVIANO AR. AQUILIZAN

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